Chapter 4 Flood Management

This Flood Management Resource Management Strategy (RMS) is unique to the RMSs contained in Volume 3 of Water Plan Update 2013 in that it contains multiple approaches within one RMS. Flood Management is complex, and still relatively new to the content of the Water Plan. For this Water Plan Update 2013, one Flood Management RMS is provided instead of multiple RMSs to provide local and regional water managers a broader perspective of the flood management tools available, and their inter-relationships, within one chapter. In future updates to the Water Plan, and as Flood Management becomes more integrated into the Water Plan, multiple RMSs related to Flood Management may be developed.

This Flood Management RMS has been subdivided into four Flood Management approaches:

- Non-Structural
- Natural Floodplain Functions Restoration
- Structural
- Emergency Management

The subsequent sections will discuss Flood Management in general terms followed by specific sub-sections related to the four approaches identified above, as necessary.

Flood Management in California

Floods are naturally occurring phenomena in California. Flooding varies according to the diversity of landscape features, climate, and human manipulation of the landscape. Flooding occurs in all regions of California at different times of the year and in different forms—examples range from tsunamis in coastal areas to alluvial fan flooding at the base of hillsides, and from fast-moving flash floods in desert regions to slow-rise deep flooding in valleys. Flooding can have positive natural impacts, such as keeping erosion and sedimentation in natural equilibrium, replenishing soils, recharging groundwater, filtering impurities, and supporting a variety of riverine and coastal floodplain habitats for some of California's most sensitive species. However, when floods occur where people live and work, they can result in tragic loss of lives and can have devastating economic impacts by damaging critical infrastructure and vital public facilities, taking valuable agricultural land out of production, and endangering California's water supply system.

Flood management includes policies and practices related to educating the public, preparing for, mitigating against, responding to, and recovering from flooding that create risk for people and valued resources, as well as protecting the natural and beneficial functions of floodplains to the maximum extent practicable. Traditional approaches to flood management included developing single-purpose flood infrastructure projects, which has resulted in an extensive network of flood infrastructure, including (DWR, 2012):

- More than 20,000 miles of levees
- More than 1,500 dams
- More than 1,000
- Many other facilities

- Many other facilities, including pump stations, monitoring facilities, bypasses, and weirs

While this infrastructure has reduced the chance of flooding and avoided damage to lives and property, it has altered and confined natural watercourses. These alterations lead to unintended consequences, such as loss of ecological function and redirection of flood risks upstream or downstream of projects. Additionally, these traditional approaches have encouraged urban and agricultural development within floodplains, which has placed people and property at risk of flooding, as well as degraded habitat.

Even with this existing infrastructure, California is still at significant risk due to flooding. Further development in flood-prone areas, population growth, and climate change will lead to increased people and property at risk of flooding in the future. While flood infrastructure can reduce the intensity and frequency of flooding, it cannot completely eliminate the flood risk (e.g., residual flood risk will still remain). *California's Flood Future Report: Recommendations for Managing the State's Flood Risk* (Flood Future Report, 2013), a companion plan to the Water Plan, characterized the potential for flood exposure in California. More than 7 million people and $580 billion in assets (crops, buildings, and public infrastructure) are currently exposed in the 500-year floodplains in California (DWR, 2012). A detailed description of flood risks in California can be found in the Flood Future Report at http://www.water.ca.gov/sfmp/ (DWR, 2012).

Today, Flood Management is evolving from narrowly focused traditional approaches towards an integrated water management (IWM) approach. The Flood Management emphasis has shifted to a more integrated approach that includes a mix of multiple measures, including structural and non-structural approaches and approaches that enhance the ability of undeveloped floodplains and other open spaces to behave more naturally and absorb, store, and slowly release floodwaters during small and medium-sized events. The application of Flood Management approaches within the context of an IWM approach extends the range of strategies that may be employed over the traditional approach. Additionally, the approaches that may be implemented to manage flood risk within a hydrologic region or watershed will vary depending on the physical attributes of the area, the presence of undeveloped floodplains, the type of flood hazards (e.g., riverine, alluvial fan, coastal, etc.), and the areal extent of flooding.

Although the primary purpose of Flood Management is public safety (i.e., reduce flood risk and reduce the impacts of flooding on lives and property), approaches within Flood Management can serve many purposes and Flood Management is a key component of an IWM approach. Flood Management as part of an IWM approach considers land and water resources at a watershed scale, employs both structural and nonstructural measures to maximize the benefits of floodplains and minimize loss of

Flood Management within the Context of an Integrated Water Management Approach

Integrated water management (IWM) is an approach that combines specific flood management, water supply, and ecosystem actions to deliver multiple benefits. An IWM approach uses a collection of tools, plans, and actions to achieve efficient and sustainable solutions for the beneficial uses of water. An IWM approach reinforces the interrelation of different water management components—such as water supply reliability, flood management, and environmental stewardship—with the understanding that changes in the management of one component will affect the others. This approach applied to flood management looks at the benefits of flooding to natural systems. This approach also promotes system flexibility and resiliency to accommodate changing conditions such as regional preferences, ecosystem needs, climate change, flood or drought events or financing capabilities.

An IWM approach requires unprecedented alignment and cooperation among public agencies, tribal entities, land owners, interest-based groups, and other stakeholders. It is not a one-time activity but rather an ongoing process. Also, this approach relies on blending knowledge from a variety of disciplines, including engineering, planning, economics, environmental science, public policy, and public information.

An IWM approach represents the future of flood management in California, with the ultimate goal of achieving long-term economic stability, public safety, and enhancement of environmental stewardship.

life and damage to property from flooding, and recognizes the benefits to ecosystems from periodic flooding.

Flood Management

Flood Management includes a wide range of management actions, which may be grouped into four general approaches: Non-Structural Approaches, Natural Floodplain Functions Restoration, Structural Approaches, and Emergency Management. These approaches and the management actions within them serve as a toolkit of potential actions that local, State, and Federal agencies can use to address flood-related issues, and advance IWM.

These actions range from policy or institutional changes to operational and physical changes to flood infrastructure. Such actions are not specific recommendations for implementation; rather, they serve as a suite of generic management tools that can be used individually or combined for specific application situations. Management actions can also be integrated with other resource management strategies under other objectives (e.g., water supply, water quality, ecosystem restoration, and recreation) to create multiple-benefit projects.

There are several management actions within Flood Management that are considered to be cross-cutting (i.e., they would be a part of all resource management strategies). These cross-cutting actions are permitting, policy and regulations, and finance and revenue. Volume 1 of the Water Plan provides more details on these potential cross-cutting actions; however, Table 4-1 describes how these actions relate to improved flood management.

Table 4-1. Cross-Cutting Management Actions and their Relationship to Flood Management

Management Action	Description
Permitting	Regional and programmatic permitting methods can provide faster and better delivery of flood management activities, including operations, maintenance, repair, habitat enhancement and restoration, and minor infrastructure improvement or construction projects. Regional and programmatic permitting methods can be used to collectively manage permitting needs for multiple projects, over longer planning horizons, while consolidating mitigation and conservation efforts into larger, more viable conservation areas. This can accelerate permitting of flood system projects and lower per-unit costs versus project-by-project mitigation. Regional and programmatic permitting methods include regional Habitat Conservation Plans, Natural Community Conservation Plans, programmatic Endangered Species Act (ESA) Section 7 consultations, and Regional General Permits.
Policy and Regulations	Policies and regulations that clarify flood management roles and responsibilities for local, regional, State, and Federal agencies can help improve coordination across the large number of agencies and entities involved in flood management. Multiple jurisdictional and regional partnerships can also be encouraged for flood planning and flood management activities, including permitting, financing, operation and maintenance, repair, and restoration.
Finance and Revenue	Several finance and revenue strategies can increase the ability to fund flood management projects. Aligning flood management projects with other existing or planned projects (such as roads or highways) leverages funding from different agencies and jurisdictions to help accomplish objectives. Consolidating projects on a regional or watershed level can also improve cost effectiveness and financial feasibility by pooling resources.

Non-Structural Approaches

Non-structural approaches to flood management include: a) Land Use Planning and b) Floodplain Management.

Land Use Planning

Land use planning employs policies and regulations to limit development in flood-prone areas and encourages land uses that are compatible with floodplain functions. This can include policies and regulations that restrict or prohibit development within floodplains, restrict size and placement of structures, prevent new development from providing adverse flood impacts to existing structures, encourage reduction of impervious areas, require floodproofing of buildings, and encourage long-term restoration of streams and floodplains.

Floodplain Management

Floodplain management generally refers to nonstructural actions to floodplains that reduce flood damages and losses. Floodplain management actions include:

- **Floodplain Mapping and Risk Assessment –** Floodplain mapping and risk assessment serve a crucial role in identifying properties that are at a high risk to flood. Local communities, State government, and the private sector require accurate, detailed maps to prepare risk assessments, guide development, prepare plans for community economic growth and infrastructure, utilize the natural and beneficial function of floodplains, and protect private and public investments. The development of needed technical information includes topographic data, hydrology, and hydraulics of streams and rivers, delineation of the areas subject to inundation, assessment of properties at risk, and calculation of the probabilities of various levels of loss from floods.
- **Land Acquisitions and Easements –** Land acquisitions and easements can be used to restore or preserve natural floodplain lands and to reduce the damages from flooding by preventing urban development. Land acquisition involves acquiring full-fee title ownership of the lands. Easements provide limited-use rights to property owned by others. Flood easements, for example, are purchased from a landowner in exchange for the perpetual right to periodically flood the property when necessary or to prohibit the planting of certain crops that would impede flood flows. Conservation easements can be used to protect agricultural or wildlife habitat lands from urban development. Although acquisition of lands or easements can be expensive, they can reduce the need for structural flood improvements that would otherwise be needed to reduce flood risk.
- **Building Codes and Floodproofing –** Building codes and floodproofing include specific measures that reduce flood damage and preserve egress routes during high-water events. These codes could require floodproofing measures that increase the resilience of buildings through structural changes, elevation, or relocation and the use of flood resistant materials.
- **Retreat –** Retreat is the permanent relocation, abandonment, or demolition of buildings and other structures. In coastal regions, this action will allow the shoreline to advance inward unimpeded in areas subject to high coastal flooding risks, high erosion rates, or future sea-level rise.
- **Flood Insurance –** Flood insurance is provided by the Federal government via the National Flood Insurance Program (NFIP) to communities that adopt and enforce an approved floodplain management ordinance to reduce future flood risk. The NFIP enables property owners in participating communities to purchase subsidized insurance as a protection against flood losses.

- **Flood Risk Awareness (Information and Education) –** Flood risk awareness is critical because it encourages prudent floodplain management. Flood hazard information is a prerequisite for sound education in understanding potential flood risks. If the public understands the potential risks, they can make decisions to reduce their risk, increase their personal safety, and expedite recovery after floods. Effective risk awareness programs are critical to building support for funding initiatives and to building a connection to the watershed.

Natural Floodplain Function Restoration

This approach recognizes that periodic flooding of undeveloped lands adjacent to rivers and streams is a natural function and can be a preferred alternative to restricting flood flows to the existing channel. The intent of natural floodplain function restoration is to preserve and/or restore the natural ability of undeveloped floodplains to absorb, hold, and slowly release floodwaters. To permit seasonal inundation of undeveloped floodplains, some structural improvements (e.g., a weir) may be needed to constrain flooding within a defined area along with nonstructural measures to limit development and permitted uses within those areas subject to periodic inundation. Actions that support natural floodplain and ecosystem functions include:

- **Natural Hydrologic, Geomorphic, and Ecological Processes –** Natural hydrologic, geomorphic, and ecological processes are a key component of promoting natural floodplain and ecosystem functions**.** Human activities (including infrastructure, such as dams, levees, channel stabilization, and bank protection) have modified natural hydrological processes by changing the extent, frequency, and duration of natural floodplain inundation. These changes have disrupted natural geomorphic processes, such as sediment erosion, transport, and deposition, which normally cause channels to migrate, be cut off, and split and rejoin downstream. These natural geomorphic processes are important drivers in creating diverse riverine, riparian, and floodplain habitat to support fish and wildlife as well as providing natural storage during flood events.. Restoration of these processes might be achieved through setting back levees, restoring channel alignment, removing unnatural hard points within channels, or purchasing lands or easements that are subject to inundation.
- **Quantity, Quality, and Connectivity of Native Floodplain Habitats –** Quantity, quality, and connectivity of native floodplain habitats are critical to promote natural floodplain and ecosystem functions**.** In some areas, native habitat types and their associated floodplain have been lost, fragmented, and degraded. Lack of linear continuity of riverine, riparian habitats, or wildlife corridors, impacts the movement of wildlife species among habitat patches and results in a lack of diversity, population complexity, and viability. This can lead to native fish and wildlife becoming rare, threatened, or endangered. Floodplain habitat creation or enhancement can be accomplished through setting back levees, expanding channels or bypasses, or through removal of infrastructure that prevents flood flows from entering floodplains.
- **Invasive Species Reduction –** Minimizing invasive species can help address problems for both flood management and ecosystems. Invasive species can reduce the effectiveness of flood management facilities by decreasing channel capacity, increasing rate of sedimentation, and increasing maintenance costs. Non-native, invasive plant species can often out-compete native plants for light, space, and nutrients, further degrading habitat quality for native fish and wildlife. These changes can supersede natural plant cover, eliminate, or reduce the quality of food sources and cover for indigenous animal species, and disrupt the food chain. Reductions in the incidence of invasive species can be achieved by defining and prioritizing invasive species of concern, mapping their occurrence, using best management practices for invasive species control, and using native species for restoration projects.

Structural Approaches

Structural approaches to flood management include: a) Flood Infrastructure, b) Reservoir and Floodplain Storage and Operations, and c) Operations and Maintenance.

Flood Infrastructure

Flood infrastructure varies significantly based on the type of flooding. Flood infrastructure can include:

- **Levees and Floodwalls –** Levees and floodwalls confine flood flows by containing the waters of a stream or lake. Levees are an earthen or rock berm constructed parallel to a stream or shore (or around a lake) to provide protection from all types of flooding. Levees could be placed close to the stream edge, or farther back (e.g., a setback levee). Ring levees could be constructed around a protected area, isolating the area from potential floodwaters.
- **Channels and Bypasses –** Channels and bypasses convey floodwaters to prevent slow-rise, flash, and debris-flow flooding. Channels can be modified by deepening and excavating the channel to increase its capacity, or lining the streambed and/or banks to increase drainage efficiency. Channel modifications can result in increased erosion downstream, degradation of adjacent wildlife habitat, and often require extensive permitting. Bypasses are structural features that divert a portion of flood flows into adjacent lands (or underground culverts) to provide additional flow-through capacity and/or to store the flows temporarily and slowly release the stored water.
- **Coastal Armoring Structures and Shoreline Stabilization –** Coastal armoring structures and shoreline stabilization protect low-lying coastal areas from flooding. Coastal armoring structures are typically massive concrete or earthen structures that keep elevated water levels from flooding interior lowlands and prevent soil from sliding seaward. The cost of armoring is justified when flooding and wave damage threatens substantial human investment. Shoreline stabilization reduces the amount of wave energy reaching a shore or restricts the loss of beach material to reduce shoreline erosion rates. Types of shoreline stabilization include breakwaters, groins, and natural and artificial reefs.
- **Debris Mitigation Structures –** For debris and alluvial flooding, Sabo dams, debris fences, and debris basins separate large debris material from debris flows, or they contains debris flows above a protected area. These structures require regular maintenance to periodically remove and dispose of debris after a flood. Deflection berms (or training berms) can be used to deflect a debris flow or debris flood away from a development area and allow debris to deposit in an area where it would cause minimal damage.

Reservoir and Floodplain Storage and Operations

Reservoir and floodplain storage and operations consist of:

- **Reservoir and Floodplain Storage –** Reservoir and floodplain storage provide an opportunity to regulate flood flows by reducing the magnitude of flood peaks occurring downstream. Reservoirs collect and store water behind a dam and release it after the storm event. Floodplain storage occurs when peak flows in a river are diverted to adjacent off-stream areas. Floodplain storage can occur naturally when floods overtop a bank and flow into adjacent lands, or the storage can be engineered using weirs, berms, or bypasses to direct flows onto adjacent lands.
- **Storage Operations –** Storage operations optimize the magnitude and timing of reservoir releases. Storage operations can reduce downstream flooding by optimizing the magnitude or timing of reservoir releases, or through greater coordination of storage operations. Coordination can take the form of formal agreements among separate jurisdictions to revise

reservoir release operations based on advanced weather and hydrology forecasts, or it can simply involve participation in coordination meetings during flood emergencies.

Operations and Maintenance

Operations and maintenance is a crucial component of Flood Management. Operations and maintenance activities can include inspection, vegetation management, sediment removal, management of encroachments and penetrations, repair or rehabilitation of structures, or erosion repairs. Because many flood facilities constructed in the early to mid-twentieth century are near or have exceeded the end of their expected service lives, adequate maintenance is critical for these flood facilities to continue functioning properly.

Flood Emergency Management

Flood emergency management includes the following preparedness, response, and recovery activities:

- **Flood Preparedness** – Flood preparedness includes the development of plans and procedures on how to respond to a flood in advance of a flood emergency, including preparation of emergency response plans, training of local response personnel, designation of evacuation procedures, conducting exercises to assess readiness, and developing emergency response agreements that address issues of liability and responsibility.
- **Emergency Response –** Emergency response is the aggregate of all those actions taken by responsible parties at the time of a flood emergency. Early warning of flood events through flood forecasting allows the timely notification of responsible authorities so that plans for evacuation of people and property can be implemented. Emergency response also includes flood fighting and emergency sheltering. Response begins with and may be confined to the affected local agencies or operational areas (counties). Depending upon the intensity of the event and the resources of the responders, regional, State and federal response may be required.
- **Post-Flood Recovery** – Recovery programs and actions include restoring utility services and public facilities, repairing flood facilities, draining flooded areas, removing debris, and assisting individuals, businesses, and communities to protect lives and property. Recovery planning can include development of long-term floodplain reconstruction strategies to determine whether reconstruction will be allowed in flood-prone areas. Such planning should review what building standards should be required, how the permit process for planned reconstruction can be improved, and how natural floodplains and ecosystem functions can be incorporated.

Connections to Other Resource Management Strategies

An IWM approach relies on the application of multiple strategies. In addition to the flood-specific strategies, other water resource management strategies included in the Water Plan Update 2013 have the potential to provide flood management benefits and may be incorporated as an element of an IWM approach.

The RMSs that share important synergies with Flood Management are described briefly below:

- **Land Use Planning and Management**: The way in which land is used—the type of land use, transportation, and level of use—has a direct relationship to Flood Management. One of the most effective ways to reduce the vulnerability to potential flooding is through land use planning that incorporates applicable flood information and flood management best practices. For example, by focusing compact development in established urban areas and avoiding more

development in floodplains, the need for expensive flood facilities can be minimized and flood risk can be reduced, protecting critical infrastructure and easing the burden on flood managers.

- **Sediment Management**: Floods have a major role in transporting and depositing unconsolidated sediment onto floodplains. Erosion and deposition help in determining the shape of the floodplain, the depth and composition of soils, the quality of river habitats, and the type and density of vegetation. Disruption of the dynamics of natural sediment transport can cause failure of adjacent levees through increased erosion or can reduce the flood-carrying capacity of natural channels through increased sedimentation. Sediment is a major component of alluvial fan and debris-flow flooding.
- **Watershed Management**: Watersheds are an appropriate organizing unit for managing floodplains. Restoring, sustaining, and enhancing watershed functions are key goals of flood management in the context of IWM.
- **Urban Runoff Management**: Urbanization creates impervious surfaces that reduce infiltration of stormwater and can alter flow pathways along with the timing and extent of flooding. Impervious surfaces increase runoff volumes and velocities, resulting in streambank erosion and potential flooding problems downstream. Urban runoff can pick up a variety of pollutants from the ground before entering streams, rivers, and coastal waters. However, watershed approaches to urban runoff management can capture, treat, and use urban runoff for beneficial uses in a manner that mimics a natural hydrologic cycle.
- **Agricultural Lands Stewardship**: Due to the flat topography and rich soils caused by historical flood deposits, floodplains are often ideal for agricultural uses. Agricultural runoff can carry pollutants, such as fertilizers, into the water system. However, responsible stewardship of agricultural lands can prevent urban development within floodplains and constrain farming and ranching practices to those areas that are compatible with floodplain management.
- **Forest Management**: Forestry practices can influence sediment transport from upland streams, as well as the timing and magnitude of peak flows. The high amount of surface roughness in forested floodplains reduces floodwater velocities, spreads flows across a larger area of the floodplain, and attenuates downstream flows. Wildfires can increase peak flows and reduce surface water infiltration, which can cause erosion and debris flooding.

Resource management strategies that are also management actions that directly contribute to Flood Management include the following:

- **Conveyance**: Many streams and channels are used to support both flood flow conveyance and water supply conveyance. Improvements to regional water supply conveyance systems could enhance the potential for flood flow conveyance, and vice versa.
- **Surface Storage**: Most of California's major surface water reservoirs are managed for multiple purposes, including water supply, hydropower, water quality, recreation, and ecosystem needs, as well as flood management. Increasing local and regional surface storage has the potential to provide greater water management flexibility for capturing runoff and controlling flood flows.
- **System Reoperation**: The primary goal of forecast-coordinated and forecast-based operations is to improve downstream flood protection while improving, or at least not degrading, water supply, environmental, or recreational uses through better hydrologic forecasting and coordinated reservoir operations.
- **Outreach and Education**: Outreach is needed to regularly educate the public on flooding, flood risks, floodproofing, and impacts of climate change, as well as to explain what households, businesses, and communities can do to reduce or mitigate risk to acceptable levels. Outreach is also needed to educate the public on the natural, beneficial functions of floodplains.

Resource management strategies that may directly benefit from the natural function of flooding include the following strategies:

- **Ecosystem Restoration**: Floodplain environments are dynamic in nature and are highly productive biological communities, given their proximity to water and the presence of fertile soils and nutrients. Native riparian and aquatic animal and plant communities of California are adapted to conditions of seasonal flooding. The principal opportunities for improvement in both flood management and ecosystem restoration occupy the same spatial footprint and are affected by the same physical processes that distribute water and sediment in rivers and across floodplains.
- **Pollution Prevention**: Floodplains that function well improve water quality by filtering impurities and nutrients, processing organic wastes, controlling erosion and sedimentation of streams, and moderating temperature fluctuations.
- **Water-Dependent Recreation**: Flood protection facilities can improve recreational access to waterways by providing opportunities for integrating suitable recreation facilities.
- **Recharge Area Protection, Conjunctive Management, and Groundwater Storage**: Diversions of flood flows for groundwater infiltration can reduce downstream flooding and improve water supply. The generally flat topography of natural floodplains and the permeable nature of alluvial soils promote infiltration into the subsurface for storage in soils and aquifers.

Potential Benefits of Flood Management

The primary benefits of flood management are derived from the potential to reduce risks to lives and property from flood events, which reduces the social and economic disruption and flood recovery costs. However, flood management also provides opportunities for water supply, environmental, water quality, recreation, hydropower, and navigation benefits. The potential benefit categories are discussed briefly below.

Table 28-1 provides a summary of potential benefits and costs of the specific Flood Management strategies and management actions.

Flood Risk Reduction Benefits

The importance of flood risk reduction to promote public safety and economic stability cannot be understated. More than 7 million people and $580 billion in assets (crops, buildings, and public infrastructure) are currently exposed in the 500-year floodplains in California (DWR, 2012). (A “500-Year Flood” has a 1-in-500, or 0.2 percent, probability of occurring in any given year) Many areas in California lack even basic protection from a 100-year flood. (A “100-Year Flood” has a 1-in-100, or 1 percent, probability of occurring in any given year) These Flood Management approaches decrease this risk by decreasing the probability of flooding and the consequences from flooding using a wide variety of actions. Flood infrastructure, operations, and maintenance can reduce the frequency, extent, and depth of flooding. Floodplain management and land use planning, as well as emergency preparedness, response and recovery, further reduce the residual risk that cannot be reduced by infrastructure alone. Limiting development in floodplains helps address the primary source of flood risk instead of merely addressing its symptoms. Without these flood risk-reduction benefits, a major flood has the potential to allow millions of citizens, homes, businesses, and agricultural lands to be flooded, critical infrastructure to go out of service for long periods of time, and isolation or closure of vital services.

Water Supply Benefits

An integrated approach to Flood Management would maximize the beneficial uses of water to improve water supply reliability, stormwater management, and groundwater recharge. An IWM approach to Flood Management would increase water supply reliability by improving the operational flexibility of multiple-purpose infrastructure such as channels and bypasses that are used for water supply and floodwater conveyance, and multiple-purpose reservoirs to store floodwaters that are later used for water supply. The restoration of ecosystem functions by reconnecting streams to their historical floodplains, setting back levees, creating floodplain storage, and acquiring easements would encourage natural groundwater recharge by providing an expansive area where floodwaters would slow in velocity, disperse over a broader area, and infiltrate.

Environmental Benefits

An integrated approach to Flood Management would enhance ecosystems by restoring the natural hydrologic, geomorphic, and ecologic processes and by improving the quantity, quality, and connectivity of riverine and coastal habitats. These actions result in healthier, self-sustaining ecosystems that provide breeding and feeding grounds for a wide variety of aquatic and terrestrial species. These actions also help maintain biodiversity by aiding in the recovery of endangered and threatened species, and control invasive species. It also increases ecosystem resiliency to uncertain changing conditions such as climate change. Integrating ecosystem conservation and restoration with flood risk-reduction projects is an essential component of Flood Management that can increase effectiveness, sustainability, and public support. Restoration of natural floodplain functions, including natural watershed features such as meadows restoration, can also attenuate peak flows.

Water Quality Benefits

The restoration of ecosystem functions as part of a flood management strategy would improve water quality through filtering nutrients and impurities from runoff, reducing levels of pathogens and toxic substances. Restored ecosystem functions also would aid in processing organic wastes, control erosion and sedimentation by stabilizing banks, and moderate temperature fluctuations by providing shade. Infrastructure, such as debris mitigation structures, can also improve water quality by reducing the amount of sediment from debris flooding.

Recreation Benefits

Integration of Flood Management and recreation can increase the number and quality of recreational areas and parks for water-oriented sports, boating, swimming, hiking, and camping. Land use planning, floodplain management, and ecosystem restoration can support recreational activities by providing areas of active and passive-use recreation in floodplains and flood greenways, increasing open space, and increasing scenic value. Even in urban areas, establishing greenways as part of flood management projects and replacing concrete channels with more natural creek environments can satisfy recreation demand.

Hydropower Benefits

California's major surface water reservoirs that are managed for flood management also generate hydropower or are hydraulically connected to reservoirs that generate hydropower. Optimizing storage operations provides more water management flexibility to achieve multiple benefits, including hydropower generation.

Navigation Benefits

Several channels and bypasses in California that are subject to flooding also provide navigation benefits when used for interstate commerce. Channel dredging operations to increase channel capacity can also provide navigation benefits.

Table 28-1: Benefits and Costs of Management Actions

Management Action	Flood Risk Reduction Benefits	Other Benefits						Costs
		Water Supply	Environmental	Recreation	Water Quality	Hydropower	Navigation	
Non-Structural Approaches								
Land Use Planning	Addresses all types of flooding. Reduces risk by reducing who and what is flooded. No reduction in residual risk.	X	X	X	X			Low initial costs. No significant change to annual costs.
Floodplain Management Floodplain Mapping and Risk Assessments	Addresses all types of flooding. Could reduce flood risk if risk assessment leads to land use decisions that are consistent with floodplain mapping data.							Low initial costs. Low to medium annual costs.
Floodplain Management Land Acquisitions and Easements	Addresses all types of flooding. Reduces risk by reducing who and what is flooded. No redirected hydraulic impacts and reduction in residual risk.	X	X	X	X			High initial costs based on location, extent, or type of easement. Costs include real estate acquisitions, relocations, mitigation costs, engineering, and permitting costs. Annual costs vary.
Flood Management Building Codes and Floodproofing	Addresses all types of flooding. Reduces who and what is flooded and the susceptibility of people and property from harmful flooding. Reduces residual risk.							Low initial costs for building code changes and costs for implementation could be recovered through additional fees. Medium to high initial costs for floodproofing depending on number of structures.
Flood Management Retreat	Addresses coastal flooding by reducing who and what is flooded and the susceptibility of people and property from harmful flooding. Reduces residual risk.		X	X				Medium to high initial costs depending on type of retreat, location, extent, type of structure, real estate acquisitions, mitigation, and permitting costs

Table 28-1: Benefits and Costs of Management Actions

Management Action	Flood Risk Reduction Benefits	Other Benefits						Costs
		Water Supply	Environmental	Recreation	Water Quality	Hydropower	Navigation	
Flood Management Flood Insurance	Addresses all types of flooding. Improves the recovery of people and property from harmful flooding. Reduces residual risk.							Low to medium initial costs. Low annual costs.
Flood Management Flood Risk Awareness – Information and Education	Addresses all types of flooding. Does not directly reduce flood risk, but reduces who and what might be flooded if it leads to land use decisions that are consistent with floodplain function. Reduces residual risk.							Low initial costs. Low to medium annual costs depending on extent of training and how flood information is disseminated.
Natural Floodplain Function Restoration								
Natural Floodplain Function Natural Hydrologic, Geomorphic, and Ecological Processes	Addresses all types of flooding. Can reduce peak flood flows and decrease the frequency, extent, and depth of flooding. No change in residual risk.	X	X	X	X			Medium to high initial costs based on size of project, real estate acquisitions, relocations, permitting, design, construction, mitigation, and loss of property taxes. Annual O&M costs could increase during establishment period but reduce annual costs over long-term.
Natural Floodplain Function Quantity, Quality, and Connectivity of Native Floodplain Habitats	Does not directly reduce flood risk. Can provide mitigation opportunities for habitat losses elsewhere for flood management. No changes in residual risk.	X	X	X	X			Highly variable initial costs depending on type of effort, real estate acquisitions, relocations, permitting, design, construction, and potential loss of property taxes. Annual costs could increase short term, but decrease long term.
Natural Floodplain Function Invasive Species	Addresses all types of flooding. Reduces the probability, extent, and depth of flooding by decreasing channel capacity and increasing rate of sedimentation.		X	X				Medium initial costs with potential costs related to permitting, maintenance, mapping, and technical evaluation on how to control invasive species. Annual maintenance costs

Table 28-1: Benefits and Costs of Management Actions

Management Action	Flood Risk Reduction Benefits	Other Benefits						Costs
		Water Supply	Environmental	Recreation	Water Quality	Hydropower	Navigation	
								would increase slightly.
Structural Approaches								
Flood Infrastructure Levees and Floodwalls	Addresses all types of flooding by reducing the frequency of flooding. Reduces the susceptibility of people and property from harmful flooding. If development is encouraged behind levees, residual risk would increase.	X[a]	X[a]	X				High initial costs, depending on location, amount, real estate needs, permitting/mitigation costs. Additional annual O&M costs required.
Flood Infrastructure Channels and Bypasses	Predominantly addresses slow-rise and flash flooding. Reduces the susceptibility of people and property from harmful flooding.	X	X	X			X	High initial costs, depending on location, amount, real estate needs, permitting/mitigation costs. Additional annual O&M costs required.
Flood Infrastructure Coastal Armoring Structures and Shoreline Stabilization	Addresses coastal flooding by reducing the frequency of flooding and reducing erosion rate. Reduces the susceptibility of people and property from harmful flooding. If development is encouraged behind armoring structures and shoreline stabilization, residual risk would increase.		X[b]	X[b]				High initial costs, depending on location, amount, real estate needs, permitting/mitigation costs. Additional annual O&M costs required.
Flood Infrastructure Debris Mitigation Structures	Addresses debris and alluvial fan flooding by retaining debris and reducing downstream flooding. Reduces the susceptibility of people and property from harmful flooding.				X			Medium-high initial costs. High annual O&M costs for debris removal and disposal.

Table 28-1: Benefits and Costs of Management Actions

Management Action	Flood Risk Reduction Benefits	Other Benefits						Costs
		Water Supply	Environmental	Recreation	Water Quality	Hydropower	Navigation	
Reservoir and Floodplain Storage and Operations Reservoir and Floodplain Storage	Addresses slow-rise and flash flooding. Reduces the probability, extent, and depth of flooding. Reduces frequency of flooding and residual risk by reducing peak flows.	X	X	X		X		Medium to very high initial costs depending on location and size of storage, real estate acquisitions, relocations, permitting/mitigation costs, complexity of facilities. Additional small annual O&M costs.
Reservoir and Floodplain Storage and Operations Storage Operations	Addresses slow-rise and flash flooding by reducing frequency and magnitude of downstream flooding and reducing residual risk. Reduces the probability, extent, and depth of flooding. Coordinated operations can involve transfer of risk, increasing risk in one area, while decreasing risk in another.	X	X	X		X		Low-medium initial costs, depending on location, extent of facilities, forecasting and hydrologic technology used. Annual costs are variable.
Operations and Maintenance	Addresses all types of flooding. Reduces vulnerability of flood infrastructure. No change in residual risk.		X				X[c]	Low initial costs. Medium to high annual costs depending on type and extent of maintenance.
Flood Emergency Management								
Emergency Management Flood Preparedness	Addresses all types of flooding. Reduces the susceptibility of people and property from harmful flooding. Reduces residual risk by reducing the consequences of flooding.							Low to medium initial costs. Low annual costs.
Emergency Management Emergency Response and Flood fighting	Addresses all types of flooding. Reduces the susceptibility of people and property from harmful flooding. Reduces residual risk by reducing the consequences of flooding							Low to medium initial costs. Low annual costs.

Table 28-1: Benefits and Costs of Management Actions

Management Action	Flood Risk Reduction Benefits	Other Benefits						Costs
		Water Supply	Environmental	Recreation	Water Quality	Hydropower	Navigation	
Emergency Management Post-Flood Recovery	Addresses all types of flooding. Does not directly reduce flood risk, but improves public safety in the aftermath of a disaster.							Low to medium initial costs. Low annual costs.

Notes:
[a] For setback levees only
[b] For natural and artificial reefs
[c] For dredging activities only

Potential Costs of Flood Management

Since Update 2009, the Department of Water Resources (DWR) has worked to identify the costs of improving flood management on a statewide basis. Included in this effort are the Central Valley Flood Protection Plan, the Flood Future Report, and regional flood management through Integrated Regional Water Management (IRWM) plans. Collectively, these efforts identified the immediate need for more than $50 billion to complete flood management improvements and projects. These flood management projects include maintenance projects and other identified actions. Research for the Flood Future Report also indicated the need for substantial additional funding to complete flood risk assessments throughout the state, and to conduct flood management improvements based on the assessments. Therefore, the total estimated capital investment needed for flood management projects could easily top $100 billion.

The costs of different management actions vary significantly. Developing a new reservoir can cost billions of dollars, while some policy and regulatory management actions can be implemented for minimal investments of time and money. In addition to the initial costs for an action, provisions must be made for long-term O&M. Costs for implementing a single management action can also vary widely based on quantity, location, real estate costs, permitting and mitigation costs, and other factors. Therefore, potential costs for flood management actions are summarized qualitatively in Table 28-1. Initial costs and annual costs for each management action were characterized with a low, medium, or high value, which represents the relative cost of the management action compared to other flood management actions.

The implementation of multi-purpose flood management projects (i.e., IWM projects) has the potential to reduce overall costs, as an integrated approach can leverage flood management benefits from a variety of projects and programs, including those focused on other forms of water resources management.

There are several cost advantages of an IWM approach due to improved delivery and implementation of flood management. Improved agency interaction through an IWM approach is at the core of implementing these advantages because a diverse set of stakeholders must coordinate, cooperate, and collaborate to develop successful IWM projects. Improved agency interaction also facilitates effective planning, agency alignment, and identification of investment priorities and funding. A key benefit of agency alignment for flood management is reduced permitting and mitigation process costs as well as improving governance and policy.

Agency alignment at all levels (local, state, and Federal agencies as well as tribal entities) also enables statewide planning to be completed that identifies governance and policy needs required to develop statewide investment priorities. Setting statewide investment priorities encourages development of integrated projects and increases the pool of available funding, making funding more reliable. Local, State, and Federal agencies and tribal entities are beginning to structure their flood management programs to support multiple-benefit projects. These multiple-benefit projects have access to different or new funding sources. Partnering with other agencies can increase flexibility for pursuing diverse funding sources to overcome grant caps and varied eligibility requirements. Coordination across geographic and agency boundaries can help agencies pool and leverage their funding to make the best use of limited human and financial resources.

Climate Change Considerations and Implications

Climate change will have a significant impact on the timing and magnitude of precipitation and runoff and contribute to a rise in sea levels. Increased air temperatures will result in more precipitation falling as rain rather than snow, contributing to increases in winter runoff. While future precipitation is somewhat uncertain, greater flood magnitudes are anticipated due to more frequent atmospheric river storm events (Dettinger, 2011). In addition, rising sea levels could increase the potential for high tides and storm surges to inundate low-lying coastal areas. Warmer temperatures and changes in soil moisture are expected to contribute to more frequent and intense wildfires. Areas damaged by these wildfires would have a greater potential for flooding associated with accelerated runoff and debris flows. These changes could change the magnitude and frequency of flood events, although specific effects may be difficult to reliably predict.

Understanding the specific effects of climate change is a significant data gap. For example, much of the current analysis of climate and water impacts considers how changes in various mean conditions (e.g., mean temperatures, average precipitation patterns, mean sea level) will affect water resources, particularly our water supply. Although many water resource factors are affected by such average conditions, some of the most important impacts, including flooding, will result not from changes in averages, but from changes in local extreme precipitation and runoff events over short periods (DWR, 2006). These extremes are difficult to project for the future because climate projections from global climate models have difficulty representing regional- and local-scale precipitation patterns and processes that drive extreme events over short time-steps. Without this information, flood planners and emergency managers have a difficult task making informed decisions about the impacts and risks of climate change.

The impacts of climate change can be addressed through mitigation and adaptation measures.

Adaptation

The anticipated changes in runoff, the frequency and magnitude of flood events, and sea level rise present serious challenges to Flood Management. However, many of the approaches presented in the flood management actions, such as setback levees, reservoir operations, floodplain management, and restoring ecosystem functions, can assist in providing more flexibility and resiliency in adapting to a changing climate. For example, levee setbacks and bypasses can provide greater protection from the anticipated changes in the timing and magnitude of precipitation and runoff and storm intensity expected due to climate change by improving flow capacity.

Incorporating climate change considerations into land use and emergency management planning decisions can also play a key role in Flood Management going forward. For example, decisions to avoid developing in or retreat from areas particularly vulnerable to sea-level rise would greatly reduce the risk of flooding and/or the need for new or larger levees, or other flood infrastructure.

Mitigation

Mitigation is accomplished by reducing or offsetting greenhouse gas emissions in an effort to lessen contributions to climate change. Structural approaches to flood risk management can lead to increased greenhouse gas emissions from the building and maintenance of facilities. These emissions can be mitigated if the project is built with the capability to generate hydropower. Flood control through land use management can cause greenhouse gases sequestered in soil to be emitted, but can also remain

largely neutral due to the lack of energy being used in the system. Floodplain restoration can also aid in mitigating climate change through carbon sequestration in soil and vegetation or riparian restoration.

Implementation Issues and Challenges Related to Flood Management

Major issues and challenges to implementing flood management initiatives were identified in the Flood Future Report, based upon interviews with more than 140 local, State, and Federal agencies, and tribal entities, with varying levels of flood management responsibilities in each county of the state (DWR, 2012). Additional issues have been identified by land use and environmental planners. Together, these issues represent the primary barriers related to implementing Flood Management:

- Issue 1: Inadequate and Unstable Funding and Incentives
- Issue 2: Inadequate Data/ Information and Inconsistent Tools
- Issue 3: Inadequate Public and Policymaker Awareness of Flood Risk
- Issue 4: Complex and Fragmented Governance Structure Impedes Agency Alignment and Systems Approach

Issue 1: Inadequate and Unstable Funding and Incentives

Current funding for flood management in California is inadequate and unreliable because it is dependent upon agency user fees, assessments, bond funding, and earmarking. Flood management program funding has been cyclical—often increasing following a flood disaster, then gradually decreasing as other priorities garner the attention of residents and policymakers. Local funding is linked to county revenue and is affected by changes in the State economy. State funding has been heavily dependent on bond funds, and to some extent the fluctuations of the General Fund. Funding of Flood Management for local agencies is hampered by Propositions 13 and 218, which restrict an agency's ability to increase property assessments. Funding from assessments or impact fees can have limitations on where the funds can be spent geographically. For example, upstream infrastructure that decreases downstream risk could not be funded in a flood management assessment district because the infrastructure is not within the district's geographic boundary. Flood management budgets are especially susceptible to reductions in dry years or economic downturns. State bond funding will be depleted by 2017, and the Federal spending on flood management is uncertain but is unlikely to be at the same levels as in the past.

Funding for Flood Management, as well as funding for an IWM approach, is inadequate to meet current needs. Funding sources and incentives have changed over time. In addition, agencies involved in Flood Management do not have clear and strong incentives from State and Federal governments to implement regional/systemwide planning and multiple-benefit solutions. Financial incentives provided to local agencies traditionally have not distinguished between supporting narrow-purpose projects implemented by a single agency and multiple-benefit projects implemented on a regional scale. Adequately incentivizing an IWM approach to Flood Management is important because it requires investments of time, energy, and staff resources for the required coordination to realize long-term benefits.

Issue 2: Inadequate Data/Information and Inconsistent Tools

Improved quantity, quality, and accessibility of data are needed in large areas of the state to close data gaps related to flood risk, floodplain mapping, hydrologic data, flood infrastructure integrity, ecosystem mapping, flood forecasting, flood readiness, and climate change.

Inadequate and outdated hydrologic and mapping data hinder the assessment of flood risk across the state. Accurate and detailed mapping is needed to guide development, prepare plans for community economic growth and infrastructure, utilize the natural and beneficial function of floodplains, and protect private and public investments. The condition of aging infrastructure is often not fully understood and can be expensive to assess. Funding is often inadequate to meet current data, assessment, and mapping needs in California.

A need also exists to increase the quality of environmental information and tools for informing flood management and conservation activities. Even in cases where data and information are available, changing conditions such as climate change add new uncertainties to existing data sets. Although much information is available online about Flood Management, including data, case studies, budget information, funding sources, and climate change and other planning tools, many data repositories have differing levels of accessibility, ease of use, and metadata requirements. Although these data exist, the sources are difficult to locate and access, and data may be inconsistent.

Other major data gaps exist that inhibit a consistent methodology to assess flood risk and measure project benefits. Different methods are used across the state to assess flood risk, which results in inconsistency. The methods include those used by the United States Army Corps of Engineers (USACE), the Federal Emergency Management Agency (FEMA), and local agencies. These methods were each developed to reach unique objectives that required different levels of complexity. For example, FEMA uses an approach that has traditionally focused on the hazards associated with the 100-year and 500-year flood events, in contrast to the USACE approach that assesses and describes risk in terms of expected annual damage (EAD).

Many of the benefits that are reaped using an IWM approach cannot be quantified monetarily, which hampers assessing and comparing different integrated solutions. Especially difficult is assigning a value to ecosystem restoration benefits. No set methodology exists to measure such benefits, resulting in an under-valuation of the benefits of IWM.

Issue 3: Inadequate Public and Policymaker Awareness and Understanding of Flood Risk

Policymakers and the public have varying levels of understanding about the risks and consequences of flooding. Historically, this has led to putting people and property at increased risk. Currently, many California residents and policymakers primarily are aware of the risk to flooding based on the need to purchase flood insurance under FEMA's NFIP. This program uses the terms 100-year and 500-year floods, leading to misunderstandings about the frequency of flooding in an area. Also, residents and policymakers believe in the infallibility of flood infrastructure, including levees. In addition, residents and policy makers are often unaware of the consequences that occur outside of the floodplain due to economic impact, loss of critical services, etc.

In addition, major floods are infrequent, separated by many years, resulting in the public underestimating flood risk. Policymakers who are responsible for land use decisions often are unaware of the consequences of their decisions, such as allowing development in floodplains where people and assets are put at risk. This lack of awareness makes it difficult to achieve sustainable, long-term planning and investment that support Flood Management and even more difficult to gain public understanding of flood risks.

Issue 4: Complex and Fragmented Governance Structure Impedes Agency Alignment and Systems Approach

Responsibilities for flood management are currently fragmented across numerous local, State, and Federal agencies and tribal entities. Flood management is often complicated by the large number of agencies and entities involved, and by their complex jurisdictional roles and responsibilities. More than 1,300 agencies have some aspect of flood management responsibility in California. Each of these agencies has unique objectives, authorities, roles, responsibilities, and jurisdictions. The fragmentation of flood management responsibilities results in poor agency alignment. Overlapping jurisdictions and conflicting missions and priorities across various local, State, and Federal agencies and tribal entities involved in Flood Management can lead to inconsistent policies, regulations, enforcement, and practices. Coordinating activities within this fragmented jurisdictional landscape can be challenging, particularly for local entities. A strong need exists for improved agency alignment through coordination of policies and guidance across multiple agencies at all levels – local, State, Federal, and tribal.

The complex and fragmented governance structure in California hinders agency alignment. Agency alignment is cooperation and collaboration toward a common IWM approach. Agency coordination issues include intra-agency, inter-agency, and coordination with regulatory and resource agencies. Improper agency alignment results in projects that are narrowly focused, in missed opportunities for integration and funding maximization, and in projects that have unintended negative impacts on downstream or upstream communities and natural environments. Agency alignment is sometimes precluded due to the fragmented governance structures. Most flood management agencies in California understand the benefits of an IWM approach but might not have the authority or resources to participate in projects that are regional or systemwide in scale.

Another consequence of improper agency alignment is inconsistent regulatory requirements, permitting, and enforcement. Unclear, conflicting, or mutually exclusive regulatory objectives or requirements can increase costs and time needed for regulatory review. Lack of consistent standards for mitigation requirements can impede project development and implementation. This can result in conflicts between competing project objectives.

Agency alignment is essential for the establishment of clear roles and responsibilities related to emergency preparedness, response, and recovery. This lack of alignment, as well as concerns about funding and cost reimbursement, can result in confusion or inaction during a flood emergency.

Recommendations

Recommendations to facilitate the implementation of flood management initiatives have been developed in response to the four major issues identified above. These recommendations are organized by the need to:

- Pursue Stable Funding and Create Incentives
- Develop and Disseminate Adequate Data and Tools
- Improve Public and Policymaker Awareness and Understanding of Flood Risk
- Strengthen Agency Alignment

Pursue Stable Funding and Create Incentives

1. **Federal and State agencies should link funding to using an IWM approach by 2017**. Incentivizing an IWM approach with State and Federal funds will encourage local agencies to consider higher-value, multiple-benefit projects when developing options for flood management. This effort could include providing incentives to all agencies and tribal interests

for regional- or systemwide-scale flood management planning that encompasses conservation and restoration, including riverine, floodplains, and other ecosystem functions. Performing planning at this broader scale for Flood Management enables a more holistic approach to water and ecosystem management. Future flood management planning and actions should proceed utilizing an IWM approach. Flood management planning based on IWM leads to better projects, reduces the need for more costly structural solutions, and promotes multiple societal benefits, including public safety, environmental stewardship, and economic stability.

2. **Local, State, and Federal agencies should work together to develop a roundtable to assess the applicability of all potential funding sources, propose new funding options, and identify needed changes to legislation by 2020**. The roundtable initially would review existing funding sources identified in the online resource catalog of flood management funding created by State and Federal agencies, review other funding mechanisms, and make recommendations. The roundtable also should propose changes or alterations to local funding restrictions by pursuing exemptions to existing statutes for public safety. For example, changes to current law (e.g., Proposition 218 legislation) could include reclassification of flood management agencies as exempted public safety utilities. The roundtable also could pursue the establishment of regional assessment districts.
3. **By 2017, State and Federal agencies should expand processes for developing, funding, and implementing flood management projects with an IWM approach in each region of the state**. The use of IWM would promote and encourage the incorporation of project components that achieve a broader range of objectives. Also, this would result in development of a common terminology for State and Federal programs to help grantors and grantees understand IWM processes.
4. **By 2020, DWR should link funding for flood management improvements to implementation of best management practices**. Fiscal incentives can help improve local land use planning to reduce risk to people and property, where feasible.
5. **By 2017**, **DWR, working with the California Emergency Management Agency (CalEMA) and other State agencies, should provide grant funding for increased coordination among flood responders, facility managers, planners, Tribal entities, and representatives of State and Federal resource agencies to improve flood emergency preparedness**. Coordination before a flood event improves emergency preparedness by identifying and reinforcing areas of expertise, available resources, and agreement about plans.
6. **State and Federal agencies should consider establishing more stable sources of funding to assist local and regional collaboration.**

Develop and Disseminate Adequate Data and Tools

7. **DWR should ensure that guidelines, tools, and technical assistance for IWM include flood management best practices by 2017. DWR should provide technical assistance to local flood management agencies that encourage an IWM approach**. Improved guidelines and technical assistance will provide tools and incentives for local implementation. Also, these best practices should promote the preservation of existing floodplains, the restoration of natural floodplain functions, and the careful analysis of the interface between natural or naturalized floodplains and structural flood management systems to ensure that erosion and debris deposition from these natural areas do not create undue hazards to downstream facilities and property.
8. **Local, State, and Federal agencies should work together to develop the methodology and data to perform regional risk assessments across the state by 2020.** These efforts will provide flood management agencies at all levels with the data and tools they need to establish and achieve appropriate levels of flood protection. Goals should be based on the number of lives and value

of property at risk, degree of urbanization, number of critical facilities, type of flood, and level of acceptable risk for the region.

9. **DWR, academic institutions, USACE, U.S. Geological Survey (USGS), and the National Oceanic and Atmospheric Administration (NOAA) should build on studies currently underway to develop a climate change report by 2017. The report would focus on climate change and its impacts on flood hydrology, concentrating on local extreme events instead of average precipitation and temperature changes**. Such a report would be valuable because flooding is impacted more by extreme events.
10. **By 2017, DWR should catalog, provide, and promote online information resources about flood risk, grants, and other related topics**. DWR should develop a comprehensive statewide database on flood management that builds on existing efforts and make the database accessible to flood management agencies and tribal entities for use as outreach materials. The database should include natural floodplain resources, land use and watershed boundaries, and updated flood hazard areas. Easy access to data, case studies, budget information, and planning tools will improve local agency capabilities to identify opportunities for collaboration and integration. Additionally, online information resources should lead to an increase in the public's overall flood risk awareness. The online resource library should include, where available, floodplain mapping, risk maps, flood awareness information, hydrologic, geomorphic, and climate change data and information, relevant ecosystem information, and other relevant information.
11. **DWR should update the Flood Future Report by 2017, and every 5 years thereafter**. The update should cover risk assessment information; address regional planning efforts (including prioritized projects), flood readiness, flood awareness initiatives, land use decision making, and agency alignment efforts in the context of IWM; include flood-related funding needs; and discuss revisions to the recommendations to improve flood management.
12. **State and Federal agencies should, with input from local agencies, develop a methodology, including indicators and metrics, for evaluating regional or systemwide benefits by 2017**. The methodology would be developed to quantify benefits, such as ecosystem restoration, recreation and open space, water supply, groundwater recharge, sustainability, and community/social benefits**.**
13. **By 2017, local, State, and Federal agencies should identify data and forecasting needs, including cost estimates, for emergency management**. Accurate and timely forecasts for flood events can increase warning time, save lives, and reduce property damage. Additional data will help improve the readiness and response to floods. Providing data and tools to improve system operations will improve overall management of natural and man-made flood systems.
14. **By 2017, DWR should release the next update of the Central Valley Flood Protection Plan.** Updates to the CVFPP will be prepared by DWR and its partner agencies (including the USACE, the Central Valley Flood Protection Board, and local agencies) every five years. Following adoption of the first CVFPP by the Central Valley Flood Protection Board in 2012, the next update is due in 2017.

Improve Public and Policymaker Awareness and Understanding of Flood Risk

15. **To assist local planning agencies, DWR, in consultation with local governments and organizations that represent flood management and land use professionals, should develop planning principles and criteria that will help decision makers determine if property is at risk for flooding by 2017**. These principles should be promoted as "best management practices" to increase prudent land use planning. These principles should promote the preservation of existing floodplains and the restoration of natural floodplain functions, where feasible. The planning principles should recognize the unique differences of rural, suburban, and urban

California. These best practices should include definition of the "no adverse impact" philosophy for project planning.

16. **By 2017, local, State, and Federal agencies and tribal entities should be working together to leverage existing flood management awareness initiatives and share outreach programs tools, templates, and other resource materials to local agencies.**

Strengthen Agency Alignment

17. **Local, State, and Federal agencies should pursue a regional permitting process to avoid limitations of compensatory mitigation, allow more landscape restoration opportunities, and facilitate more efficient permitting processes for project execution.**
18. **By 2017, local, State, and Federal agencies should develop a plan to conduct regular flood emergency preparedness and response exercises statewide and increase participation among public agencies at all levels in flood-fight training**. Regular training, tabletop drills, a participation in training and functional exercises are a necessary part of disaster preparedness.
19. **By 2015, local, State, and Federal agencies should identify regional flood planning areas**. Flood management planning areas are needed throughout the state with boundaries that are systemwide, watershed based where feasible, and consistent with existing Federal and State agency boundaries, including existing IRWM funding areas and existing California Water Plan planning areas. By organizing regional planning areas hydrologically, these areas will be better able to address issues that impact a united group of stakeholders. Also, such areas would enable the complex array of flood management agencies to begin working together to resolve common issues on a regional basis.
20. **By 2020, State and Federal agencies should realign existing internal processes to support regional groups that undertake regional flood planning by addressing statutes that impede this realignment**. State and Federal agencies can modify internal agency processes and programs that would assist local agencies in removing the barriers to expediting project delivery and promoting multiple benefits projects. This effort should include the development of common terminology for State and Federal programs, which would help agencies communicate the varying aspects and benefits of multiple-objective projects, as well as remove the statutes that impede agency alignment.
21. **By 2017, resource agencies should collaborate to develop a permitting guidebook that includes a description of the relevant permits, permit applications, and permitting guidance**. The guidance would include a description of the types of permits that are required for flood management projects and guidelines for when such permits are needed, explicit lists of what information permitting agencies require to issue these permits, and explanations of how and when to coordinate with regulatory agencies for project-specific and regional permitting approaches.
22. **By 2017, resource agencies should give priority to permitting projects that include a public safety purpose**. Prioritizing public safety projects, including flood management, will protect lives, property, and sensitive habitats.

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